FINAL REPORT

W-49-R(SI)-32

"Onset, Etiology and Significance of Disease in Rabbits in southern Illinois"

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FINAL REPORT

STATE OF ILLINOIS

W-49-R(SI)-32 STUDY I Job 3

Project Period: July 1, 1982 through June 30, 1985

Study I: Cottontail Rabbit Investigations

Job No. 3: Determine Onset, Etiology and Significance of Disease in Rabbits in southern Illinois

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Need:

Rabbit harvests have rather consistently declined over the past decade in Illinois; loss of habitat has been suggested the major causative factor. Cottontail rabbits (*Sylvilagus floridanus*) are subject to many environmental variables and decimating factors including temperature, rainfall, cover and food availability, disease, predation, and perhaps above all, habitat change. However, populations have also declined, or experienced major die-offs where habitat quality remains suitable. Various diseases, singularly or in concert, may be responsible for these declines; these need be delineated and their significance in population regulation assessed.

Objective:

To determine the mortality factors limiting rabbit populations in selected areas of Illinois; and to determine the etiology of diseases, especially zoonotic diseases.

INTRODUCTION

Status and Literature Background

Rabbit populations are known, or suspected to be declining throughout their range. Bailey (1968a) suggested that synchronous fluctuations of abundance in the northeast and north-central regions occur; however, trends over the past 2 decades are generally downward. Certainly populations fluctuate in response to many limiting factors; but, over time land-use changes and resulting loss of habitat have exerted a major influence on rabbit abundance (Edwards et al. 1981). However, some populations seem to be lower than the habitat could support. The cause(s) of low populations in areas where habitat appears excellent are not universal, nor are they easy to define. Another aspect of rabbit population ecology is an apparent high density in spring and early summer, yet few rabbits seem present during fall when hunters are afield. It is possible that behavioral patterns make cottontails less visable in the fall. Giles (1980) found rabbits were most visible in July and August, but the number observed dropped to near zero in October. Concurrent trapping revealed densities of 2.65/ha in October versus peak densities of 2.82/ha suggesting that mortality was less than visual observation suggested.

Despite some evidence that declines may be fluctuations rather than absolute and that visibility bias may overestimate losses in some instances low populations in good habitat have been documented (Jacobson et al. 1978a). Further, the progressive loss of rabbits between breeding and hunting seasons has been reported by numerous workers. Various diseases and etiological agents have been incriminated in these losses including myiasis, coccidiosis, gastrointestinal helminths, Tyzzer's disease, tuleremia, and viruses. Thus nearly

, every category of infectious disease has been reported.

Various diseases, singularly or in concert, may be underlying causes of local population declines. If present land-use trends continue to compartmentalize cottontail habitats, disease could become an even more important regulatory factor. Some aspects of diseases have been studied in Illinois (Yeatter and Thompson 1943, Ecke and Yeatter 1956, Stannard and Pictsch 1958, Mohr and Lord 1960, Ferris et al. 1960, 1961); these were conducted in times of relative rabbit abundance and did not address regulatory potential.

STUDY AREAS

Wayne Fitzgerrell State Park (WFSP)

WFSP, located in Franklin and Jefferson counties about 10 km north of Benton, Illinois, was dedicated as a multiple use recreation area in October 1975. Farming was the dominant land use prior to acquisition and development as a park; many fence rows, abandoned crop fields, cleared farmsteads and small woodlots remained. An abundant rabbit population was evident; 2,645 rabbits were harvested in December 1975 during a 23 day controlled hunt. The following year 17 hunting days yielded but 246 rabbits. This substantial harvest reduction may have been attributable to overharvest, but winter 1975 was mild and good production would have been expected spring and summer 1976. Noteworthy was the statewide trend which showed a higher average season bag in 1976 than in 1975 (Ellis 1979).

Rabbit hunts were not conducted at WFSP 1977-1980, and by 1980 recovery to high levels was evident. In summer 1980 a major die-off was reported. Expected recovery did not occur; the population was severely depressed in winter 1981 due either to a lack of recovery from the 1980 die-off or continued action of the mortality factor(s).

Between park dedication and present, there has been unusual consistency in crop patterns and attention to providing good wildlife cover. The Illinois Department of Conservation (IDOC) presently manages about 1,440 ha, approximately one-third of which is used for hunting and field trials. Crop production through agricultural leases has averaged about 112 ha. In addition, 10-12 ha have been annually planted to millet, buckwheat, milo and various grasses as wildlife food patches.

Cooperative Wildlife Research Laboratory Annex

Semi-captive populations of rabbits were established in 1983 and 1984 in a 1.48 ha outdoor enclosure about 1 km west of the main Southern Illinois University Campus at Carbondale, Jackson County, Illinois. The enclosure site is well drained with a gentle slope. Grasses and blackberry (*Rubus allegheniensis*) provide vegetative cover. Mowing was utilized to intersperse cover, control blackberry spread, and aid observations. Previous cottontail studies in this enclosure (Yaich 1981) documented epizootics of unknown etiology.

METHODS

Population Monitoring

Wayne Fitzgerrell State Park

The WFSP population was monitored by a 32 km non-repeat km auto census route including most roads in and around the park. Sporadic, but usually monthly censuses began September 1982 and continued until a biweekly schedule was initiated March 1984. Censuses began about 1 hour before sunset and took about 2 hours to complete. Number

and location of cottontails were recorded. Incidentally observed mammals and birds were also noted.

Enclosure Population

In January-March 1983 and 1984, 20 and 31 rabbits were live trapped and stocked in the 1.46 ha enclosure. Captured rabbits were anesthetized with about 40 mg/kg ketamin HCl for examination; they were sexed, aged (adult or juvenile), and breeding condition noted. Standard measurements were taken, physical condition assessed, and 10 mls blood collected via cardiac puncture for packed cell volume determination, serum chemistry and tularemia testing. Tags were inserted in both ears for subsequent identification, then animals were released into the enclosure. A pelleted rabbit feed was provided ad libitum in 5 feeders.

The populations were monitored by evening observation periods and daily searches. In 1984, 9 activity monitoring radio-transmitters were attached to rabbits to enhance monitoring for mortality.

Collection and Necropsy

Beginning in May 1983 and June 1984, biweekly collections of 5 juveniles from the enclosure were attempted. Wooden box traps baited with apple quarters were used plus shooting with a .22 caliber rifle. When juvenile numbers were low, adults also were collected. An attempt was made to eradicate the enclosure population by October in 1983. A similar attempt was made in November 1984.

When biweekly collection quotas were almost complete and further efforts in the pen were futile, rabbits were shot in an adjacent pen (the West pen) or along the Wildlife Annex's road. Rabbits were also collected in Crab Orchard NWR in 1983 and WFSP in 1984.

Shot animals were immediately placed in a white enamel tray to collect ectoparasites leaving the cooling body. Blood for serology and tularemia testing was aspirated from the bullet wound; blood for packed cell volume (PVC) determination was collected in 75 mm heparinized micro-hematocrit capillary tubes from free-flowing blood. Cardiac puncture was attempted to collect all blood possible. The carcass was then placed in a plastic bag containing an ether soaked paper towel, placed on ice, and transported to the lab. Processing in the lab was completed as soon as possible. In 1984, all processing occurred the same day the animal was collected.

Live-trapped animals were transported to the lab and anesthetized with Ketamine HCl. Blood for PCV, serology, and tularemia testing was collected via cardiac puncture; death was by exsanguination.

Total length, ear length, tarsus length, and body weight were recorded. The animal was then skinned. Fresh weights of liver (g), spleen (g), kidneys (g), total fat (abdominal, visceral, and interscapular) (g), and adrenals (mg) were recorded; a Triple Beam Balance and an electronic analytical balance were used. Stomach, small intestine, and large intestine were ligated to prevent post-mortem gastrointestinal (GI) helminth migration. The GI tract and pelt then were refrigerated or frozen. Whenever possible, both were examined for parasites within one or two days of the rabbit's death. Fecal samples were also collected from the rectum and preserved in potassium dichromate (7.5% solution).

Any general rabbit abnormalities were recorded during the necropsy. Bailey's (1968b) weight-length relationship and Chapman et al.'s (1977) adrenal index were used to quantify physical condition.

All tissue evidencing gross lesions and sections of liver, spleen,

heart, lung, brain, and kidney were collected and stored in 10% neutral buffered (NB) formalin. Histological slides, initially stained with H & E, were prepared by personnel of the SIU-C Medical School Histology Lab. Eyeballs were collected and stored in 10% NB formalin. Eye lens weights were later derived using Lord's (1959) methodology.

Parasitology

Ectoparasites were collected from pelts by carefully parting the hair. Beginning in September 1983 and extending for all the 1984 necropsies, the pelts were then digested in a potassium hydroxide solution (39.7 g pelleted KOH, 800 ml water). Skins were placed in Erlenmeyer flasks containing the digest solution, heated to approximately 90 degrees C. on a hot plate for about 4 hrs, and drained through a 250 mm sieve. Ticks and fleas from digested pelts, those collected through cursory examination of pelts, and others which had dropped off during processing were counted, collected and stored in glycerin-alcohol (95 parts 70% ethanol, 5 parts glycerine). The storage medium was changed to 70% ethanol in 1984. Ectoparasites were identified, sexed, and aged with the aid of a variable power zoom dissecting micros cope with a double magnifier. Criteria of Cooley and Kohls (1944, 1945) and Furman and Catts (1982) were used to identify ectoparasites.During initial processing, a general inspection of the peritoneal, pleural, and pericardial cavities, body musculature, mesenteries, and subcutaneous areas were made to locate, count and collect helminths.

The stomach, small intestine and large intestine were split with scissors and the mucosa scraped with a scalpel handle. Scrapings and tissues were washed with tap water; all wash water was collected and serially decanted until clear. Large and small intestinal tissue

was discarded but the stomach was examined at 7x with a dissecting microcope to locate worms embedded in mucosa. All substrates from washings were similarly examined at 7x. Helminths were counted, collected and stored.

All helminths were initially stored in glycerine-alcohol. Beginning in September 1983, cestodes and trematodes were fixed and stored in glycerine-alcohol. When possible, live worms were killed and fixed in hot fixative to ensure quality specimens.

Total counts were obtained for nematodes and cestodes; however, when trematode numbers were high (> 3000), a dilution counting technique was used. Two 10 ml aliquotes were taken and the trematodes counted. If the 2 subsamples were within 10% of each other, an average was taken and multiplied by the total volume of the sample/10. If the subsamples were not within 10% of each other, a third 10 ml aliquot was counted and the 3 subsamples were averaged.

Nematodes were cleared in glycerine by allowing the alcohol in the glycerine-alcohol to slowly evaporate and then mounted in glycerine jelly. Cestodes and trematodes were stained progressively and regressively with Semichon's Aceto-carmine and mounted in Canada balsam. Papers by Erickson (1947), McCrae (1956), Skrjabin (1954, 1964, and 1969), Stiles (1896), and Yamaguti (1959, 1961) aided in the identification of endoparasites. In addition, a McMaster's fecal counting chamber was used to count helminth eggs and coccidal oocysts.

Microbiology

Swabs of heart blood, lung, and small intestine were collected aseptically using sterile swabs and immediately cultured or refrigerated overnight. Each sample was examined by direct smear using a gram

stain then aerobically cultured for at least 48-72 hours using commercially prepared enriched broth and agar plates. Any growth was identified by a combination of colony characteristics, standard microbiological procedures, and commercial identification kits (Analytab Products). All microbiological preparations and cultures were performed by personnel of the SIU-C Vivarium diagnostic Laboratory.

Isolation and identification of Francisella tularensis was attempted by Dr. Meir Lev of the Department of Microbiology, SIU-C. Standard tularemia isolation techniques were used on frozen liver sections.

Hematology and serology

Blood collected in heparinized capillary tubes was spun in a microhematocrit centrifuge for 5 minutes. Packed cell volume (PVC) was determined by measuring the length of the volume of red blood cells (mm) / total length of the blood sample (mm) in the capillary tube. Reported PVC is an average of tubes collected from each rabbit.

Blood collected for serology and tularemia testing was allowed to clot. Sera was separated by low speed centrifugation (3000 rpm, 5 min.), pipetted into vials, and stored at -20 degrees C. until analysis. Commercially prepared antigen and antibodies (Difco Lab.) were used to conduct rapid slide agglutination tests to detect titers against Francisella tularensis. A second serum aliquot from the same rabbit was sent to Dr. Morris Cooper (Department of Medical Microbiology and Immunology, SIU-C School of Medicine, Springfield, IL.) who performed enzyme-linked-immunoabsorbent-assays (ELISA) for tularemia. A third serum aliquot was analyzed for serological components. A Technicon SMA II Auto Serum Analyzer available through Memorial Hospital in Carbondale was used to measure sodium (Na), potassium

KO, chloride (Cl), calcium (Ca), inorganic phosphorus (IN.P.), serum glutamic oxaloacetic transaminase (SGOT), serum pyruvic transaminase (SGPT), creatine phospokinase (CPK), lactic dehydrogenase (LDH), alkaline phosphatase (A.P.), creatinine (CREA), uric acid (U.A.), blood urea nitrogen (BUN), carbon dioxide (CO_2), bilirubin (BILI), albumin, (ALB), total protein (T.P.), albumin/globulin ratio (A/G), osmolarity (OSMOL), glucose (GLU H), and cholesterol (CHOL ENZ).

RESULTS AND DISCUSSION

Wayne Fitzgerrell State Park

The population at WFSP remained depressed throughout the study precluding routine rabbit collections. Fifty-one auto censuses were conducted 8 September 1982-12 June 1985 (Table 1). Rabbits were seen during only 3 of 14 censuses between September 1982-June 1983; the maximum number seen was 4 on 8 June. Between July 1983 and June 1984 censuses indicated a depressed population, but 24 were seen on 15 March providing the first evidence of over winter survival and population recovery. The census index again declined between July-September 1984; the highest count was 12 during July censuses. From September 1984 through March 1985 fewer rabbits were seen than during the preceeding winter; the peak count was 7 rabbits on 6 March. Initiation of population recovery was evidenced April-June 1985; a peak count of 30 rabbits was made 12 June.

The auto censuses revealed a very depressed population seemingly unable to recover quickly. Pockets of rabbits surviving the 1980 epizootic persisted mainly south of Rt. 183 and along the NE boundary of the park adjacent to Rend Lake College. Distribution of rabbits

Table 1. Number of cottontail rabbits seen during auto censuses at Wayne Fitzgerrell State Park, Franklin and Jefferson counties, southern Illinois, September 1982 through June 1985. Average census route, including repeat mileage, was 50.6 kilometers.

	1982		1983		1984		1985	
Month	Day	#Rabbits	Day	#	Day	#	Day	#
January			18	0	20	0	16	2
February							16	4
					16	3	20	0
March			12	0	15	24	6	7
					30	15	20	5
April					16	9	3	19
			26	0	30	4	17	1
May					15	1	1	10
					29	0	15	16
June			8	4	14	5	1	20
			15	0	29	12	12	30
July			17	0	14	12		
					27	12		
August			17	0	10	7		
					24	8		
September	8	1			6	1		
	13	0	13	0				
	15	0						
	20	0			19	0		
	22	0						
	27	0						
	29	0						
October			19	0	5	1		
					31	0		
November	8	1			14	0		
	22	0	17	0	28	0		
December			15	0				

remained very localized through 1984 as evidenced by auto censuses, winter snow tracking and incidental observations. April-June 1985 observations indicated a more widespread distribution through the park.

Reasons for the slow recovery are unclear. Because of the park's relative isolation, immigration probably contributed little to population recovery except along the NE boundary. In spite of the potential for high recruitment, it apparently was inadequate to substantially surpass mortality factors between 1981-85; only population maintenance at a low level was evident. Only 6 animals were collected in 1984; 3 were seropositive to tularemia suggesting endemic disease remained in the population that could have prevented recovery.

Rabbit Enclosure

Young of the year were first observed on 18 May and 23 March in 1983 and 1984, respectively. More time spent in the pen in 1984 may account for this difference. No evidence of any die-offs in 1983 or 1984 was noticed.

Abundance indices for both years indicated good overall recruitment. Regression lines plotting the mean number of rabbits per 5 minute scan against week of observation were significant (1983, r=0.711; 1984, r=0.94). Both plots showed a negative relationship between abundance index and week of observation (1983, mean # rabbits = -0.218 (week) + 4.010; 1984, mean # rabbits = -0.51 (week) + 8.48). Relationships between regression lines and number of rabbits potentially available each week for observation indicated indices were reliable. The biweekly collections controlled population size throughout the study period.

Essentially the enclosure populations provided baseline data representing high density, healthy rabbits.

Collection and Necropsy

Forty-seven and 90 cottontails were necropsied in 1983 and 1984, respectively (Table 2). Thirty-six of 1983 necropsies and 73 of 1984 necropsies were animals collected from the enclosure. General body and physiological measurements and weights appear in Appendix I (1983) and Appendix II (1984). Physiological weights and measures included: body weight; right, left, and total adrenal and kidney weights; total fat weight (included visceral, kidney, and interscapular fat); spleen and liver weights; and eye lens weights. Indices included adrenal index and Bailey's condition index (Table 3). Rabbits in 1984 had larger adrenals, kidneys, eye lens, and adrenal indices than 1983 rabbits; 1984 rabbits also had a lower Bailey's condition index. Differing cottontail densities within the enclosure between the two years may explain this difference. Most variations seen in the physiological weights and measures of 1983 and 1984 rabbits were attributable to age derived from eye lens weight. In both years, the few rabbits collected from Crab Orchard NWR had significantly larger adrenals and adrenal indices than enclosure animals. Nutritional stress of Crab Orchard NWR rabbits may explain this difference as those in the enclosure were on a high plane of nutrition. In 1984, the Bailey's indices from 6 rabbits collected at WFSP were significantly higher than those from Crab Orchard NWR; low densities in WFSP and a correspondingly high plane of nutrition may explain this difference.

Table 2. Number of cottontail rabbits necropsied in southern Illinois in 1983, 1984, and 1985. Unless otherwise indicated, rabbits originated from the Cooperative Wildlife Research Laboratory's enclosure.

Month	Age	1983		1984		1985	
		males	females	males	females	males	females
January	adult						
	juvenile						
February	adult			2	1 (W)	1	1
	juvenile			0	0	0	0
March	adult			2 (2C)	4 (3C,1R)	1	1
	juvenile			0	1	0	0
April	adult			0	0		
	juvenile			4	5 (1R)		
May	adult	0	1	0	1 (J)		
	juvenile	4	2	0	0		
June	adult	0	0	2 (2W)	1		
	juvenile	3	5 (1R)	3	3 (1W)		
July	adult	3 (3C)	1 (C)	0	1 (W)		
	juvenile	4 (1C)	2	5	5 (1W)		
August	adult	0	1 (R)	1	0		
	juvenile	4 (2R)	6 (2P)	4	4		
September	adult			0	4 (1W)		
	juvenile			5 (1R)	3		
October	adult	2	5	1	1		
	juvenile	2	2	6	4		

Table 2 continued.

Month	Age	1983 males	1983 females	1984 males	1984 females	1985 males	1985 females
November	adult			6	4		
	juvenile			1	1		
December	adult			1	0		
	juvenile			0	0		
Total	adult	5	8	15	17	2	2
	juvenile	17	17	28	26	0	0
		22	25	43	43	2	2

A = Wildlife annex road, the road immediately adjacent to the rabbit enclosure.
C = Crab Orchard National Wildlife Refuge.
W = Wayne Fitzgerrell State Park.
P = West pen, pen immediately adjacent to rabbit pen.
J = Jackson County, animal delivered by County Animal Control Officer.

Table 3. Means, ranges, and 95% confidence intervals of physiological weights and measures of cottontails collected in 1983 and 1984 in southern Illinois.

Parameter		n	mean	range	95% CI (±)
Body weight (g)		135	833.6	15.0 -1730.0	81.8
Adrenal weight (mg)	Right	127	62.5	3.7 - 175.1	7.2
	Left	128	83.7	3.9 - 255.4	10.3
	Total	127	146.3	7.6 - 418.5	17.5
Kidney weight (g)	Right	128	2.8	0.4 - 5.5	0.2
	Left	127	2.7	0.4 - 5.4	0.2
	Total	127	5.5	0.8 - 10.6	0.4
Total fat weight (g)		127	4.6	0.0 - 55.4	1.6
Liver weight (g)		103	22.9	0.9 - 62.9	2.7
Spleen weight (g)		136	1.2	0.4 - 8.5	0.2
Eye lens weight (mg)		112	144.1	22.1 - 288.8	16.0
Adrenal index		126	8.27	3.97- 18.66	0.48
Bailey's index		127	6.02	4.32- 8.64	0.14

Parasitology

Four ticks, Haemaphysalis leporis-palustris, Ixodes dentatus, Amblyomma americana, and Dermacentor variabilis, 2 fleas, Cediopsylla simplex and Odontopsyllus multispinosus, and 1 dipteran, Cuterebra spp. infested cottontails (Table 4). D. variabilis were not recovered from 1984 rabbits and O. multispinosus were not recovered from 1983 rabbits. Nymphs and larvae of H. leporis-palustris, adults and larvae of I. dentatus, and C. simplex infestations were significantly larger in 1984 than in 1983; total ectoparasites and the ectoparasite index (total ectoparasites/body weight x 100) were also significantly larger in 1984 than in 1983. Density of cottontails in 1984 and 1983 may explain this difference but it is cautioned that the epizootiologies of these ectoparasites were not examined. Most variations seen with ectoparasitic infestations related to seasonality of occurrence. As previously found, adult ticks reach greatest abundance in spring and early summer, larvae and nymph ticks reached abundance peaks in fall, and C. simplex was most abundant during winter. WFSP rabbits had significantly lower infestations with H. leporis-palustris nymphs and larvae and significantly lower total ectoparasite and ectoparasite indices than did enclosure and Crab Orchard NWR rabbits. Reduced population levels in WFSP since the die-off may offer an explanation.

Little pathology was seen in association with ectoparasite infestations. Some small (<5 mm) whitish purulent subcutaneous abscesses accompanied with erythema were noticed beneath tick attachment sites and a whitish-red cheesy material was commonly found within bot fly larvae capsules. The median intensity of H. leporis-palustris infestation was well above

ble 4. Prevalence and intensity of infestation with arthropods of cottontails collected southern Illinois in 1983 and 1984.

Ectoparasite	1983		1984	
	Prevalence	Number of parasites	Prevalence	Number of parasites
arina:				
emaphysalis leporis-palustris	47(96)[a]	130(1-1670)[a]	80(94)	498(2-3933)
odes dentatus	47(51)	10(1-270)	80(83)	9(1-577)
blyomma americana	47(17)	5(1-88)	80(5)	1(1-8)
rmacentor variabilis	47(2)	1(1)	80(0)	-
phonaptera:				
diopsylla simplex	47(15)	1(1-2)	80(34)	2(1-60)
ontopsyllus multispinosus	47(0)	-	80(8)	1(1-2)
otera:				
terebra spp.[b]	47(4)	2(2-3)	80(18)	1(1-3)

revalence = number of cottontails examined (% infected); median intensity and range).

ncludes wounds from bot fly larvae as well as actual recovery of larvae in 984.

[illegible]

"heavy infestations" indicated by other workers as causing significant pathology and host mortality, but we did not find similar effects.

Six nematodes, Obeliscoides cuniculi, Trichostrongylus calcaratus, Trichostrongylus affinis, Longistriata noviberiae, Dermatoxys veligera, and Trichuris spp.; 2 cestodes, Cittotaenia spp. and Taenia pisiformis, and 1 fluke, Hasstilesia tricolor, were recovered from cottontails; helminth eggs and coccidian oocysts were also found in fecal pellets (Table 5). O. cuniculi, T. calcaratus, total Trichostrongylus, L. noviberiae, total nematodes, T. pisiformis, total cestodes, H. tricolor, total helminths, and coccidian infections as well as the helminth index were significantly larger in 1984 than in 1983. A gradual build-up of infective intermediate stages of these parasites as well as a higher density of rabbits in the enclosure in 1984 may explain the difference between years.

Most variations seen with endoparasite infections related to seasonality. As previously reported, O. cuniculi and T. affinis infections peak in summer while Cittotaenia spp. and H. tricolor infections peak in fall and winter, respectively. WFSP cottontails had significantly lower burdens of O. cuniculi, T. calcaratus, T. affinis, total Trichostrongylus, L. noviberiae, and total nematodes than did pen and/or Crab Orchard NWR rabbits. Again, the reduced population levels in WFSP since the die-off probably explains this areal difference.

Little if any significant pathology was seen in association with endoparasite infections. Localized, mild gastric hemorrhages in the immediate area of embedded O. cuniculi were found infrequently; whereas, yellowish-white, minute serosal and parenchymal hepatic granulomas

Table 5. Prevalence and intensity of infection with helminths and coccidia of cottontails collected in southern Illinois in 1983 and 1984.

Parasite	1983		1984	
	Prevalence	Number of Parasites	Prevalence	Number of Parasites
Nematoda:				
Obeliscoides cuniculi	45(84)[a]	20(1-149)[a]	80(93)	38(1-306)
Trichostrongylus calcaratus	45(67)	39(1-542)	80(75)	111(3-1098)
T. affinis	45(56)	28(6-460)	80(64)	66(3-629)
T. spp.	45(24)	8(1-17)	80(24)	2(1-21)
Longistriata noviberiae	45(53)	4(1-26)	80(75)	12(1-356)
Dermatoxys veligera	45(4)	1(1)	80(1)	5(5)
Trichuris spp.	45(20)	1(1-2)	80(20)	2(1-12)
Cestoda:				
Cittotaenia spp.	45(64)	25(1-207)	80(91)	18(1-133)
Taenia pisiformis	47(11)	4(1-20)	80(46)	13(1-217)
Trematoda:				
Hasstilesia tricolor	45(24)	462(24-5066)	80(75)	1116(1-26159)
Fecal floats:[b]				
Helminth eggs	47(67)	525(50-46100)	74(65)	500(50-4800)
Coccidian oocysts	47(80)	3200(50-97600)	74(99)	4650(50-757550)

[a] Prevalence = number of cottontails examined (% infected); median intensity and (range).

[b] Per gram feces.

were commonly seen with migrating *T. pisiformis* larvae. Median intensities and ranges of infections of endoparasites recovered did not vary consistently when compared to similar data from other studies.

Microbiology

Escherichia coli, *Staphylococcus epidermis*, and *Streptococcus* spp., were routinely isolated from heart, lung, and small intestine swabs and cultures (Table 6). Only two potential pathogens, *Staphylococcus aureus* and *Streptococcus pneumonia*, were isolated; neither animal from which these originated, showed signs of disease although mild, focal parasitic pneumonia was tentatively diagnosed by histopathology in one animal. A bacteremia caused by a group D Streptococcus was implicated in the death of one animal which had whitish cauliflower-like lesions on its liver and spleen from which the bacteria in question was isolated.

Serology

Previously unreported reference values were obtained for sodium (Na), potassium (K), glucose (GLU H), uric acid (U.A.), calcium (Ca), creatinine (CREA), alkaline phosphatase (AP), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), albumin/globulin ratio (A/G), and osmolality (OSMOL). In addition, basic line values comparable to other studies were compiled for packed cell volume (PCV), albumin (ALB), blood urea nitrogen (BUN), bilirubin (BILI), total protein (T.P.), and cholesterol (CHOL ENZ) (Table 7).

Age and sex of rabbit as well as year, method, month, season, and location of collection all singularily and in concert, affected the serological variables.

Endo- and ectoparasite burdens and eye lens weights entered maximum

Table 6. Prevalence of bacteria isolated from the heart, lung, and small intestine of cottontails collected in southern Illinois in 1983 and 1984.

	1983 n=39			1984 n=70		
	Heart	Lung	Sm. Int.	Heart	Lung	Sm. Int.
Escherichia coli	7(18)	8(21)	24(62)	3(4)	1(1)	37(53)
Straphylococcus epidermis	2(5)	11(28)	4(10)		1(1)	2(3)
Streptococcus (alpha, gamma, Group D enterococcus, non-enterococcus)	2(5)	10(26)	3(8)			15(21)
Bacillus spp.	4(10)	2(5)	3(8)			
gram negative rods	3(8)		2(5)			
gram positive rods	1(3)	2(5)	1(3)			
Diphtheroids		3(8)				
Enterobacter cloacae	1(3)				1(1)	1(1)
Enterobacter agglomerans	1(3)	1(3)			1(1)	
Pseudomonas maltophila	1(3)					
Pseudomonas fluorescens	1(3)					
Pseudomonas spp.		1(3)	1(3)			
Aeromonas hydrophilia	1(3)	1(3)				
Klebsiella oxytoca			1(3)			
gram positive cocci		1(3)				
Staphylococcus, coagulase negative					1(1)	
Staphylococcus aureus *	1(3)	1(3)				
Streptococcus pneumonia *		1(3)				
Proteus mirabilis				1(1)		

Prevalence = number infected (% infected).

*Possible pathogen.

Table 7. Means, ranges, and 95% confidence intervals of seriological parameters of cottontails collected in southern Illinois in 1983 and 1984.

Parameter	n	mean	range	95% CI (±)
PCV (%)	102	36.2	17.6- 49.0	1.5
Na (mEq/l)	85	138.1	119 -151	1.2
K (mEq/l)	47	6.5	4.0- 9.7	0.4
CI (mEq/l)	85	100.8	84 -115	1.5
GLU H (mg/dl)	84	227.6	38 -398	16.0
BUN (mg/dl)	85	21.2	7 - 55	2.3
U.A. (mg/dl)	85	1.8	0.4- 7.9	0.2
CHOL ENZ (mg/dl)	85	37.6	5 -201	5.6
ALB (g/dl)	85	2.8	1.6- 4.3	0.1
Ca (mg/dl)	85	10.9	6.4- 15.0	1.6
CREA (mg/dl)	82	1.1	0.1- 2.0	0.1
BILI (mg/dl)	82	0.2	0.0- 0.5	0.02
AP(U/l)	50	91.1	18 -350	17.6
SGOT (U/l)	48	116.2	26 -293	20.5
SGPT (U/l)	50	92.0	34 -296	17.3
TP (g/l)	42	5.5	3.8- 8.3	0.3
A/G ratio	42	1.2	0.5- 1.7	0.1
OSMOL (mOsm/l)	42	227.1	235 -296	3.3

R^2 stepwise regression equations for some serological and physiological parameters with both positive and negative slopes. The associations between parasite burdens and serological parameters and parasite burdens and physiological parameters were not consistent from year to year. Deviations in the levels of serological and physiological parameters indicative of disease processes were not seen; parasite burdens may not have reached or exceeded a threshold level beyond which parasitism becomes disease detectable by serum chemistry or physiological values outside of normal ranges.

Tularemia

Seroprevalences of antibodies to tularemia detectable by the enzyme-linked-immuno-absorbent-assay (ELISA) in necropsied cottontails in 1983 and 1984 were 26 and 25%, respectively. In addition, 7 rabbits had serial blood samples of which at least one sample was seropositive; 3 animals gained titers, 2 animals lost titers, and 2 animals maintained titers, one of which had a 1:160 titer in March, August, and November samples. Francisella tularensis neartica or tularemia type A was successfully cultured and isolated from the frozen liver of a rabbit which exhibited no signs of tularemia and was seronegative for tularemia antibodies.

Three of six rabbits collected from WFSP possessed tularemia titers, one possessed the greatest titer recorded (1:2,560). It appears that tularemia is enzootic in the WFSP population. Presumptively, tularemia caused the 1980-81 die-off at WFSP, and enzootic tularemia combined with the "island" setting of the park may have delayed population recovery.

Conclusions and Recommendations

Baseline data were established that will have value in assessing

population health. Hematology/serum chemistry reference values are becoming increasingly important diagnostic tools to assess both clinical and nutritional status. Levels for PCV, ALB, BUN, BILI (Jacobson et al. 1978a, 1978b) and CHOL ENZ (Warren and Kirkpatrick 1978) were previously published for cottontails. We evaluated these plus provide new information on levels of Na, Cl, GLU H, U.A., Ca, CO_2, and CREA. Comparable reference values exist (Mitruka and Rawnsley 1981) for similar animals, including laboratory rabbits (Oreytolagus cuniculus and Lepus europaeus) and black-tailed jack rabbits (L. californicus).

Numerous variables may affect hematological/serum chemistry values, hence, "normal" must be viewed as a range. Important variables include sex, age, season, diet, and method of handling/collection. If variables are considered when interpreting deviation from a normal range, the data can be used to judge "normal" versus "diseased" rabbits, or to compare health status of populations over time or space. The more useful indicators seem to be PCV, BUN, ALB and TP. Data from low, moderate and high density populations, and from morbid animals are needed to validate these preliminary conclusions.

Parasitological results of this study are comparable to the literature in terms of ecto- and endoparasitic faunas, prevalence and intensity and ranges of infestations/infections. Significantly, we found no evidence of deleterious pathological effects of parasitism; only local tissue response was noted. At the levels we documented, parasitic diseases do not appear an important mortality factor of cottontails.

Necropsy, histopathology and microbiology did not reveal presence of diseases that were important mortality factors. Culture did detect

bacteria that are potential pathogens, but they were cultured from clinically normal rabbits and were considered normal flora. Bacterial disease caused by a group D Streptococcus was diagnosed in a morbid diagnostic case. Clinical disease was not evident in collected specimens.

The most significant finding was culture of type A tularemia from a single, clinically normal rabbit. This single case demonstrated endemic tularemia, and represented the only pathogen found with high potential to be an important mortality factor.

Serology provided further strong evidence for the presence of endemic tularemia in rabbits from 3 areas of southern Illinois. Seroprevalence of tularemia in cottontails is usually low (Andrews et al. 1980, Burgdorfer et al. 1974, McKeever et al. 1958). Early researchers interpreted low prevalence as an indication that cottontails do not survive tularemia (Jellison 1961, Yeatter and Thompson 1943).

Jellison et al. (1961) suggested that with the exception of predation, tularemia is the most frequent cause of death in cottontails. Drastic die-offs have been documented (McCahan et al. 1962, McGinnes 1964) and tularemia has been implicated in continuous declines in populations in Virginia (Jacobson et al. 1978a).

Jacobson et al. (1978a) reported a maximum prevalence of seropositive animals of 23% (4/17) during fall (Sep.-Oct.); no seropositive animals were seen the other three seasons. In the present study, overall prevalence was 26% by ELISA. Although month of collection was significantly related to ELISA titer, no monthly differences were seen.

The ELISA test developed during this study affords a sensitive, rapid and reliable diagnostic screening tool. It could be applied to testing for evidence of endemic tularemia where habitat quality

does not seem responsible for low rabbit abundance. Harvest strategies, especially for controlled hunting areas, could be applied to maximize hunting opportunity while concurrently keeping the population at a moderate density when risk of epizootic is less than at high density. This is an oversimplification, but does illustrate how management can address disease control.

The enclosure population at the Wildlife Annex did not experience significant mortality throughout the summer except that imposed by biweekly collections. Specifically, parasitic disease was discounted as a mortality factor; and, while microbiology revealed presences of potential pathogens, all isolates were obtained from clinically normal animals. Tularemia was the only potential pathogen documented by serology and 1 isolate; clinical disease was not detected.

Trauma (predation) was the only potentially important mortality factor not operative in the enclosure. An illustration of the potential of trauma (a non-infectious disease) to influence rabbit abundance was the control exerted by biweekly collections. Affects of immigration/emigration on abundance were minimal due to the secure fence; otherwise, the enclosure mimiced what might occur in any local area.

Rabbits at WFSP have been extremely slow to recover from the 1980 epizootic. Recovery equivalent to that evidenced by 1976 harvest data following the very high 1975 harvest did not occur suggesting that either 1) the epizootic was widespread and severe throughout the park, leaving too few animals to allow recovery solely by reproductive capacity, or 2) enzootic disease (probably tularemia) remains in the population as an additive mortality factory limiting recovery potential. Although its role cannot be discounted, there is no evidence that predator abundance

is unusually high and is limiting rate of recovery. Habitat quality was not directly assessed, but superficially appears to have remained consistent 1980-1985, therefore, it is discounted as a limiting factor. That the few animals sampled were in excellent condition as evidenced by necropsy and Bailey's index supports this assumption.

The relative isolation of WFSP -- near "island" setting -- may illustrate the important role of immigration in maintaining rabbit populations, or in the recovery process following decimation from any causes. As available habitats become more "compartmentalized" and populations are geographically isolated, local scarcity, or even absence, in spite of suitable habitat, may be more commonplace. This hypothesized importance should be tested in a field situation; WFSP is an ideal setting for such study.

If our hypotheses are not rejected by testing, several management strategies are suggested. First, as previously noted, harvests at "controlled" areas should be planned when populations are "moderately" abundant rather than waiting for peak density. Secondly, reintroduction or supplemental releases by trap and transplant may be necessary to create or maintain harvestable populations in some areas. Clearly, a future need for intensive management seems evident.

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Appendix I. Collection method and location, date, sex, age, body weights and measures, and organ weights of cottontail rabbits necropsied in 1983.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	kidneys L.	kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
83R01	Shot	Main	16 May	F	J	640	440	83	55	0.58	17.11	0.2	2.5	2.6	46.1	32.4
83R02	Shot	Main	16 May	F	A	1410	550	98	70	1.30	37.10	29.3	4.4	4.7	92.7	69.3
83R03	Shot	Main	16 May	F	J	690	455	80	63	1.90	26.70	0.3	2.5	2.6	44.4	36.2
83R04	Trap	Main	17 May	M	J	635	480	84	64	0.70	23.80	T	2.2	2.2	57.1	39.9
83R05	Trap	Main	18 May	M	J	735	495	84	63	0.30	25.90	1.3	2.7	2.8	74.7	52.3
83R06	Trap	Main	31 May	M	J	240	310	56	44	0.20	7.90	0.8	1.1	1.2	18.1	16.0
83R07	Trap	Main	31 May	M	J	239	328	55	45	0.10	7.60	0.3	1.1	1.2	19.6	14.0
83R08	Trap	Main	7 June	M	J	180	305	54	42	0.13	6.50	0.2	0.9	0.9	19.2	11.8
83R09	Shot	Main	13 June	F	J	218	321	60	39	0.20	6.10	1.0	1.4	1.3	15.6	11.8
83R10	Hand	Main	13 June	M	J	131	237	42	30	0.10	5.80	4.2	0.7	0.7	8.4	7.1
83R11	Trap	Main	13 June	M	J	327	385	67	53	1.00	12.60	T	1.3	1.4	33.4	31.2
83R12	Hand	Road	13 June	F	J	121	263	48	34	0.04	4.00	T	0.6	0.7	13.3	10.1
83R13	Trap	Main	13 June	F	J	196	305	56	44	0.08	7.20	2.2	1.2	1.1	16.6	13.3
83R14	Shot	Main	13 June	F	J	425	385	69	52	0.62	15.20	0.6	1.7	1.8	24.1	25.2
83R15	Trap	Main	14 June	F	J	300	343	60	47	0.08	9.60	T	1.3	1.4	32.8	22.5
83R16	Shot	Crab	6 July	M	A	1260	565	97	72	3.40	33.10	8.6	3.2	3.1	207.1	163.4
83R17	Shot	Crab	6 July	M	J	288	330	61	51	0.30	6.00*	1.7	1.5	1.4	16.0	14.7
83R18	Trap	Main	11 July	M	J	450	421	70	55	0.80	13.50	T	1.8	1.7	37.7	29.9
83R19	Trap	Main	11 July	M	J	243	356	56	55	0.25	8.60	T	1.2	1.3	27.6	21.9
83R20	Shot	Main	12 July	M	J	409	402	62	56	0.80	14.40	T	1.6	1.8	36.2	28.8
83R21	Shot	Main	12 July	F	J	670	462	81	63	0.90	19.80	0.2	1.9	2.2	50.4	40.6
83R22	Shot	Main	12 July	F	J	518	415	74	59	1.20	18.20	0.6	2.2	2.5	40.8	36.1
83R23	Shot	Crab	27 July	F	A	1573	592	99	69	1.00	36.40	30.4	3.7	3.9	113.6	74.8
83R24	Shot	Crab	27 July	M	A	1258	585	101	72	1.00	30.70	5.3	3.1	3.2	201.1	163.0

Appendix I. continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot	ear[e]	Organ & Tissue Wts. (g) spleen	liver	fat[f]	kidneys L.	kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
83R25	Shot	Crab	27 July	M	A	1413	585	101	71	1.40	33.80	4.1	3.4	3.5	225.7	159.7
83R26	Shot	Road	8 Aug	M	J	315	362	63	60	1.60	12.60	T	1.8	1.7	36.5	28.6
83R27	Shot	Main	8 Aug	F	J	675	489	84	69	0.30	21.80	1.3	2.0	2.2	64.1	54.6
83R28	Shot	Main	9 Aug	M	J	666	496	88	74	1.50	23.40*	3.6	2.5	2.3	40.8	35.5
83R29	Shot	Road	9 Aug	F	A	1730	605	99	70	1.70	48.90	3.0	5.4	4.9	105.3	78.3
83R30	Trap	Main	10 Aug	M	J	705	520	93	66	0.40	27.70	5.2	2.1	2.3	49.5	37.5
83R31	Dog	Road	15 Aug	M	J	89	248	45	36	0.28	2.90	1.2	0.6	0.7	5.5	6.2
83R32	Shot	Main	29 Aug	F	J	348	357	67	59	0.22	12.90	10.3	1.4	1.4	31.2	20.5
83R33	Shot	West	29 Aug	F	J	874	526	88	72	3.00	21.50	2.2	2.2	2.2	40.0	37.6
83R34	Shot	Main	30 Aug	F	J	694	473	87	70	1.20	26.10	1.0	2.5	2.7	38.6	29.0
83R35	Shot	Main	30 Aug	F	J	890	546	91	78	1.70	26.60	1.6	2.8	2.6	45.3	36.1
83R36	Shot	West	30 Aug	F	J	314	380	67	56	0.15	8.80	0.8	1.3	1.3	30.2	23.9
83R37	Shot	Main	3 Oct	M	J	964	530	90	69	0.90	28.50	3.7	2.6	2.9	80.0	56.8
83R38	Shot	Main	3 Oct	F	A	1446	560	95	77	2.80	41.60	6.7	3.6	3.9	66.3	51.3
83R39	Shot	Main	5 Oct	F	A	1432	585	99	77	1.10	37.00	7.9	4.6	4.5	72.4	44.6*
83R40	Shot	Main	5 Oct	F	J	1170	550	94	75	2.00	34.20	4.6	3.5	3.6	77.0	58.8
83R41	Trap	Main	10 Oct	F	J	1052	595	99	76	1.20	30.40	0.0	3.5	3.2	84.8	68.4
83R42	Trap	Main	10 Oct	M	A	1243	580	93	75	1.00	26.40	T	3.0	3.2	115.9	85.0
83R43	Trap	Main	10 Oct	M	A	1306	618	98	72	0.60	30.00	25.8	3.7	4.0	128.7	93.0
83R44	Shot	Main	11 Oct	M	J	1217	555	91	75	1.20	31.30	13.7	3.6	3.5	94.0	64.0
83R45	Shot	Main	11 Oct	F	A	1443	590	97	75	0.90	43.60	0.2	4.0	4.5	126.9	114.1

Appendix I continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
83R46	Trap	Main	12 Oct	F	A	1406	605	96	73	1.00	34.30	5.3	4.6	4.8	107.3	78.5
83R47	Trap	Main	12 Oct	F	A	1438	615	99	75	3.10	37.80	7.6	3.6	3.5	104.5	81.0

[a]Method: Hand = captured by hand.
Dog = captured by dog.

[b]Location: Main = rabbit enclosure.
Road = annex road near rabbit enclosure.
Crab = Crab Orchard National Wildlife Refuge.
West = west pen, adjacent to rabbit pen.

[c]Sex: F = female.
M = male.

[d]Age: A = adult.
J = juvenile.

[e]Foot length = hind foot length.

[f]Fat weight = combined weights of subscapular, visceral, and kidney fat.

T = trace.

* = organ damaged during collection; weight is minimum.

Appendix II. Collection method and location, date, sex, age, body weights and measures, and organ weights of cottontail rabbits necropsied in 1984.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
84R01	Dead	West	17 Feb	M	A	1150	562	88	66	0.5	32.1	19.9	3.6	3.6	113.2	73.2
84R02	Trap	West	14 Feb	F	A	1128	585	99	64	0.5	35.8	2.8	3.3	3.4	105.8	94.0
84R03	Trap	Main	15 Feb	M	A	1102	580	94	78	1.3	28.0	7.5	3.4	3.5	155.5	112.2
84R04	Trap	SIU	3 Mar	F	A	1480	630	98	74	6.3	49.3	1.4	4.7	5.1	182.0	99.1
84R05	Dead	Crab	3 Mar	F	A	1230	615	99	74	1.0	40.0	0.0	3.8	4.2	121.5	93.5
84R06	Dead	Crab	5 Mar	F	A	1246	630	98	69	1.1	31.6	0.0	4.6	4.5	163.9	119.4
84R07	Trap	Crab	9 Mar	F	A	961	580	95	65	0.8	32.5	0.1	2.5	2.5	142.4	99.5
84R08	Dead	Crab	10 Mar	M	A	1422	625	95	74	2.6	38.5	0.2	--	4.6	239.9	166.3
84R09	Trap	Crab	22 Mar	M	A	1244	620	100	70	1.7	34.6	0.0	3.3	3.1	222.2	156.0
84R10	Dead	Main	23 Mar	F	J	--	196	32	21	--	--	0.3	0.4	0.4	3.9	3.7
84R11	Dead	Main	4 Apr	M	J	18	93	14	8	0.2	2.2	0.7	0.1	0.1	13.9	12.8
84R12	Dead	Main	4 Apr	M	J	16	99	14	7	0.1	0.9	0.0	--	--	--	--
84R13	Dead	Main	4 Apr	F	J	15	95	14	10	0.1	0.9	0.6	--	--	--	--
84R14	Dead	Main	4 Apr	F	J	17	95	16	7	0.1	1.2	0.5	--	--	--	--
84R15	Dead	Main	4 Apr	F	J	17	94	15	10	0.1	1.1	0.5	--	--	--	--
84R16	Dead	Main	4 Apr	M	J	18	95	14	7	0.1	1.1	0.8	--	--	--	--
84R17	Dead	Main	7 Apr	F	J	16	110	15	7	0.1	0.9	0.5	--	--	--	--
84R18	Dead	Main	7 Apr	M	J	15	105	15	9	0.1	0.9	0.4	--	--	--	--
84R19	Dead	Cnty	18 May	F	A	1351	595	94	70	8.0	62.9	0.0	2.7	3.2	182.1	127.5
84R20	Dead	Annex	9 Apr	F	J	147	265	44	40	0.1	6.7	2.0	1.2	1.0	18.8	16.8
84R21	Shot	WFSP	18 June	M	A	1177	585	97	68	1.2	27.4+	2.6	3.5	3.5	227.2	175.5
84R22	Shot	WFSP	18 June	F	J	677	466	86	62	0.6	12.6+	T	2.1	2.3	57.0	46.1
84R23	Shot	WFSP	18 June	M	A	1259	593	94	73	0.9	29.3+	2.1	3.4	3.4	196.2	139.7
84R24	Trap	Main	25 June	M	J	446	424	76	61	0.2	10.5+	0.0	1.6	1.6	47.6	29.2

Appendix II continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot	ear[e]	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
84R25	Trap	Main	25 June	F	J	596	493	85	61	0.3	17.7+	0.0	1.9	1.9	37.0	31.0
84R26	Trap	Main	25 June	F	J	404	400	70	57	0.5	12.5+	0.0	1.5	1.5	32.7	18.2
84R27	Trap	Main	26 June	M	J	575	460	80	61	0.9	15.9+	0.0	2.2	2.0	38.5	28.5
84R28	Trap	Main	26 June	M	J	652	477	84	68	0.6	16.7+	0.0	2.6	2.8	56.5	51.0
84R29	Dead	Main	28 June	F	A	1458	604	71	100	2.8	51.8	12.3	4.7	4.9	137.5	104.6
84R30	Shot	WFSP	2 July	F	J	379	380	61	52	0.4	10.9+	T	1.4	1.5	27.3	24.1
84R31	Shot	WFSP	2 July	F	A	1367	600	94	65	0.7	29.8+	5.5	4.1	4.4	113.9	98.1
84R32	Shot	Main	9 July	M	J	350	378	67	51	0.3	10.4+	0.4	1.6	1.7	28.4	24.3
84R33	Shot	Main	9 July	F	J	329	367	66	50	0.8	10.6+	T	1.7	1.8	31.7	27.7
84R34	Shot	Main	10 July	M	J	420	427	72	58	0.3	13.6+	0.3	1.4	1.4	37.8	33.9
84R35	Shot	Main	10 July	M	J	568	440	73	61	0.8	18.0+	0.3	2.1	2.2	44.1	34.2
84R36	Shot	Main	10 July	M	J	627	473	81	61	1.0	20.5+	T	2.3	2.3	64.6	51.2
84R37	Dead	Main	22 July	M	J	--	--	--	--	--	--	--	--	--	--	--
84R38	Trap	Main	23 July	F	J	370	420	72	55	0.4	10.1	0.0	1.5	1.7	48.4	39.4
84R39	Shot	Main	23 July	F	J	434	397	71	51	0.3	13.7	0.1	1.8	1.8	43.1	35.2
84R40	Hand	Main	29 July	F	J	647	480	75	61	1.9	20.0	T	2.4	2.4	66.8	56.7
84R41	Shot	Main	6 Aug	F	J	420	420	71	53	0.2	12.1	0.2	1.7	1.8	29.0	24.4
84R42	Trap	Main	7 Aug	F	J	550	448	89	62	0.6	9.7	0.0	1.9	2.1	62.5	50.6
84R43	Shot	Main	7 Aug	F	J	564	421	70	57	0.9	17.5	1.4	2.1	2.4	43.4	30.7
84R44	Shot	Main	7 Aug	M	A	1171	570	95	66	1.4	23.0	0.4	2.6	2.9	115.4	88.5
84R45	Trap	Main	19 Aug	F	J	615	470	80	59	0.7	18.8	0.1	2.1	2.0	49.9	40.3
84R46	Trap	Main	20 Aug	M	J	522	443	77	54	0.7	19.4	1.5	1.9	2.0	40.1	33.5
84R47	Trap	Main	20 Aug	M	J	632	475	80	61	0.6	19.5	T	1.9	1.9	45.1	36.1
84R48	Trap	Main	21 Aug	M	J	478	436	73	54	0.4	13.9	T	1.7	1.8	29.2	27.8

Appendix II continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	R.
84R49	Trap	Main	21 Aug	M	J	289	365	63	46	0.2	10.2	0.7	1.3	1.4	37.2	28.4
84R50	Trap	Main	2 Sept	F	A	1403	621	98	69	1.2	36.7	T	4.4	4.5	98.9	70.8
84R51	Trap	Main	2 Sept	M	J	628	488	85	61	0.6	17.3	0.0	2.0	2.0	37.7	27.9
84R52	Trap	Main	3 Sept	F	A	1274	607	92	70	1.5	29.5	0.0	3.0	3.1	86.6	63.0
84R53	Trap	Main	3 Sept	F	A	1414	625	94	72	2.8	43.7	0.0	3.2	3.5	79.1	74.2
84R54	Trap	Main	4 Sept	M	J	255	370	66	49	0.2	4.6	T	1.1	1.2	35.4	24.8
84R55	Shot	WFSP	11 Sept	F	A	1502	600	97	74	0.5	42.9+	2.1	4.6	4.5	173.8	134.2
84R56	Trap	Main	16 Sept	F	J	535	465	81	59	0.5	12.6	0.0	1.7	1.7	49.1	42.1
84R57	Trap	Main	16 Sept	M	J	1108	580	95	67	1.1	30.6	7.2	2.8	2.7	107.4	63.3
84R58	Trap	Main	17 Sept	M	J	557	470	82	61	0.2	13.0	0.0	2.3	2.4	66.7	47.7
84R59	Trap	Main	17 Sept	F	J	463	438	74	58	0.6	13.6	0.0	1.9	2.0	49.1	44.7
84R60	Shot	Road	18 Sept	M	J	1130	600	96	71	1.1	16.7	0.5	2.7	2.5	118.1	90.8
84R61	Trap	Main	30 Sept	M	J	621	483	84	59	0.6	19.0	T	2.2	2.2	45.5	41.2
84R62	Trap	Main	1 Oct	M	J	796	525	90	65	1.4	22.9	T	2.7	3.0	62.6	50.9
84R63	Trap	Main	1 Oct	M	J	1028	560	92	57	2.9	27.6	0.0	3.3	3.3	95.9	84.3
84R64	Trap	Main	2 Oct	M	J	673	476	82	63	1.1	25.5	0.6	2.6	2.7	56.8	38.3
84R65	Trap	Main	2 Oct	M	J	762	501	85	63	2.6	25.1	T	3.0	3.0	53.0	44.9
84R66	Trap	Main	8 Oct	F	J	632	500	85	63	1.2	17.6	T	2.4	2.4	53.0	52.2
84R67	Trap	Main	16 Oct	F	J	1416	640	100	72	2.5	35.2	1.2	3.6	3.7	86.9	66.2
84R68	Trap	Main	17 Oct	M	A	1256	597	91	71	1.3	38.8	1.7	3.7	3.6	89.3	61.8
84R69	Trap	Main	17 Oct	F	A	1517	650	96	71	2.6	37.1	1.1	4.1	4.3	132.2	94.0
84R70	Trap	Main	21 Oct	F	J	1256	611	101	72	3.8	28.3	0.3	3.0	3.1	83.5	76.2
84R71	Trap	Main	21 Oct	M	J	590	473	82	62	1.0	17.9	T	2.0	2.0	53.5	47.4
84R72	Trap	Main	22 Oct	F	J	1240	595	93	70	0.9	45.5	1.3	3.5	3.3	95.2	80.8

Appendix II continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
84R73	Trap	Main	22 Oct	M	J	1310	615	94	67	1.9	36.3	12.8	3.4	3.8	72.1	57.0
84R74	Shot	Main	2 Nov	M	A	1403	590	90	76	3.0	46.8+	5.4	4.4	4.6	166.0	98.8
84R75	Shot	Main	2 Nov	F	A	1296	592	95	65	8.5	37.5+	1.4	3.6	4.2	128.5	103.0
84R76	Shot	Main	2 Nov	M	A	1292	593	98	78	1.7	35.3+	4.2	3.1	3.5	138.1	100.0
84R77	Shot	Main	4 Nov	F	J	1259	598	96	74	3.1	33.3+	11.2	3.5	3.6	67.5	53.1
84R78	Shot	Main	4 Nov	M	J	1268	620	96	75	1.8	30.6+	0.3	3.6	3.6	93.9	68.3
84R79	Shot	Main	4 Nov	M	A	1412	615	96	72	2.6	42.2+	10.9	3.9	4.2	79.9	46.2
84R80	Trap	Main	6 Nov	F	A	1428	610	96	73	1.2	43.6	31.2	4.1	4.4	63.3	50.0
84R81	Shot	Main	30 Nov	M	A	1176	585	90	70	1.6	27.8+	22.0	3.4	3.7	167.5	98.3
84R82	Shot	Main	30 Nov	F	A	1377	610	98	74	1.0	27.2+	16.4	4.4	4.5	105.2	61.7
84R83	Shot	Main	30 Nov	F	A	1448	612	98	66	1.9	38.2+	38.4	4.6	4.7	126.0	85.2
84R84	Shot	Main	30 Nov	M	A	1383	618	103	68	1.6	28.8+	55.4	3.8	4.1	126.9	88.3
84R85	Shot	Main	30 Nov	M	A	1455	619	96	68	2.0	32.3+	48.2	3.8	4.1	184.6	140.9
84R86	Shot	Main	6 Dec	M	A	1119	620	100	69	0.9	31.6+	--	5.1	5.5	249.9	167.7
84R87	Trap	Main	25 Feb	F	A	1242	604	92	67	2.2	35.9	12.8	3.8	3.9	161.6	126.3

Appendix II continued.

Necropsy number	Method[a]	Location[b]	Date	Sex[c]	Age[d]	Body Wt. (g)	Body Lengths (mm) Total	foot[e]	ear	Organ & Tissue Wts. (g) spleen	liver	fat[f]	Kidneys L.	Kidneys R.	Adrenals (mg) L.	Adrenals (mg) R.
84R88	Trap	Main	28 Feb	M	A	1383	634	101	75	1.0	39.1	7.4	3.3	3.4	255.4	163.1
84R89	Shot	Main	14 Mar	F	A	1410	613	102	71	2.7	34.7+	15.5	3.8	4.2	114.2	78.6
84R90	Shot	Main	14 Mar	M	A	1265	576	95	70	3.3	24.8+	9.0	3.7	3.6	151.6	93.8

[a]Method: Dead = animal found dead.
Hand = catured by hand.

[b]Location: Main = rabbit enclosure.
Road = annex road near rabbit enclosure.
Annex = in vicinity of annex house.
SIU = within 2 km of rabbit enclosure.
Cnty = Jackson county; Delivered by Animal Control Officer.
Crab = Crab Orchard National Wildlife Refuge.
WFSP = Wayne Fitzgerrell State Park.
West = west pen, adjacent to rabbit pen.

[c]Sex: F = female.
M = male.

[d]Age: A = adult.
J = juvenile.

[e]Foot length = hind foot length.

[f]Fat weight = combined weigths of interscapular, visceral, and kidney fat.

T = trace.

\+ = weight does not include section taken for histopathology.